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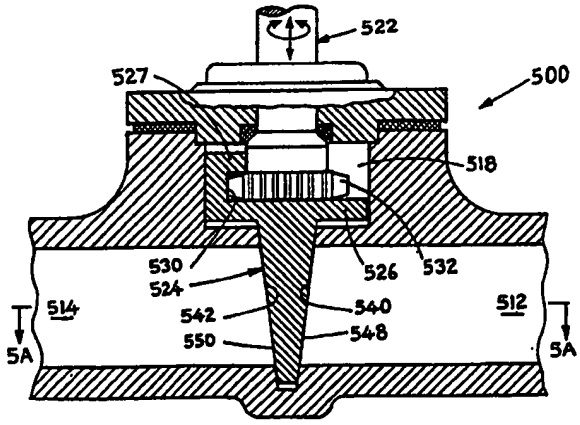
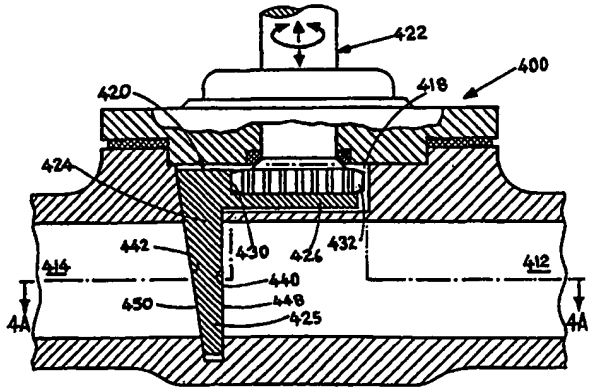
(54) Title: GATE VALVE

(57) Abstract

A valve (400) comprising a tapered wedge gate closure member (424) which is actuated by a stem (422) that is operatively connected with the valve operator at the upper end, the lower end of the stem connected to a toothed pinion (432) engaging an arcuate toothed rack (430) on the gate (424), or to a toothed pinion (532) engaging a linearly straight toothed rack (530) on the gate (524), thereby reciprocating the gate (424) across the fluid flow path (412–414) in a direction transverse to the stem axis, and the stem (422) is operatively connected with the valve operator by means of a stem moving means that causes selective axial and rotary movement of the stem (422).





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GATE VALVE

Field of the Invention

The present invention relates to a gate valve in which a tapered gate is mechanically wedged against the valve body seats for closing the valve.

Brief Description of Prior Art

Many valves have been taught in the prior art wherein a gate closure member wedges against the valve body seating surfaces in order to seal the fluid flow passageway. Examples are a tapered wedge gate valve, a tapered plug valve, an expanding wedge gate valve, etc.

A gate valve is generally understood to mean a valve in which the gate closure member reciprocates along the stem axis between the closed and the open position of the valve. In a tapered wedge gate valve, a tapered gate of solid cross section is wedged into like tapered valve body seats to sealingly close the fluid flow passageway. In order to open the fluid flow passageway, the gate is pulled away from the body seats along the stem axis. In other words, the gate reciprocates along the stem axis between open and closed positions of the valve and therefore sufficient space should be provided for in the body cavity to accommodate the movement of the gate. This cavity space is detrimental for valves in sanitary applications because debris can accumulate in the body cavity. Another disadvantage of the valve is that the fluid flow passageway cannot be sealed from the body cavity in the valve open position because the gate is pulled away from the body seats. It is also well known that the stem packing around the stem is subject to more wear in a reciprocating stem than in a rotary stem.

The most disadvantageous feature of the prior art valve is that suspended particles in the fluid get trapped between the sealing surfaces when the tapered gate is wedged mechanically against the body seating surfaces, thereby compromising sealing integrity.

So it would be advantageous to have a reciprocating gate valve that is actuated by a rotary stem for the stem packing to last longer.

The tapered wedge gate valve of prior art is very prevalent in the industry today and has been for quite some time for centuries. In fact, the tapered wedge gate valve was first invented by the Chinese when they used a tapered wooden piece to wedge into a hollow bamboo pipe to stop water flow. That was some 6000 years ago. The present invention seeks to improve upon the Chinese valve.

Summary of the present Invention

It is the essence of the present invention that the disadvantages of the prior art valve can be overcome if the tapered gate is made to reciprocate in a direction transverse to the stem axis between open and closed positions of the valve and the present invention is concerned with providing a valve in which the gate is actuated by a rotary stem for the advantages obtained therefrom.

A valve comprises a valve body having a fluid flow passageway defining a fluid flow path through the valve body and having a body cavity in the fluid flow path, the valve body having a pair of seating surfaces surrounding the fluid flow passageway and facing each other across the body cavity. The closure member in the form of a tapered gate is disposed in the body cavity and is rotatable about the stem axis or about an offset axis parallel to the stem axis which is disposed transverse to the fluid flow path. The stem is connected to the gate which is actuated by the stem to selectively open or close the fluid flow passageway. The valve body cavity is correspondingly shaped to closely surround the gate and to permit the gate to rotate about an axis transverse to the fluid flow path and to permit the gate to reciprocate in a direction transverse to the stem axis between open and closed positions of the valve. The axis of rotation of the gate can coincide with the stem axis or can be offset from the stem axis but parallel to it.

The flow control member comprising the tapered gate closure member is connected to the valve operator means which consists of a valve operator, a stem and a stem moving means. The stem is connected to the gate and the stem moving means operatively connects the valve operator and the stem for selectively moving the stem.

The stem moving means in the form of a Lift-and-Turn mechanism or a Lift-Turn-and-Reseat mechanism causes selective axial and rotary movement of the stem. The axial motion of the stem causes the flow control member to wedge against the body seating surfaces to sealingly close the fluid flow passageway. The rotary motion of the stem causes the flow control member to reciprocate in a direction transverse to the stem axis between open and closed positions of the valve because the rotary motion of the stem is translated into rotary motion of the flow control member. The stem is either rigidly connected to the flow control member or by a connecting means such as a rack and pinion arrangement between the flow control member and the stem by which the flow control member is rotated about an offset axis parallel to the stem axis. If the distance between this offset axis and the

stem axis is made larger and larger to infinity, then the flow control member reciprocates in a straight line direction transverse to the stem axis. In a Lift-and-Turn mechanism the stem is lifted a limited extent and then rotated. By lifting the stem a limited extent the wedging load on the gate is relieved thereby facilitating the rotation of the gate. In a Lift-Turn-and-Reseat mechanism the stem is lifted a limited extent, rotated and then lowered or reseated to load the gate for sealing the fluid flow passageway in the valve open position.

The advantage of the flow control member reciprocating transverse to the stem axis is that the sealing surfaces slide over each other in a wiping action as in a ball valve, when the flow control member moves between open and closed positions of the valve, thereby permitting the valve to be used with fluids with particles in suspension, e,g. slurries. Secondly, since the flow control member does not reciprocate along the stem axis between open and closed positions of the valve, the dead cavity space in the body cavity is kept to the absolute minimum, thereby making the valve of the instant invention better for sanitary applications. Thirdly, the body cavity of the instant valve can be sealed from the fluid flow passageway in the fluid flow open position of the valve by using the stem moving means in the form of a Lift-Turn-and-Reseat mechanism by which the fluid flow conduit portion of the flow control member is wedged against the body seating surfaces for sealing about the fluid flow passageway in the valve open position. Thus, a Lift-Turn-and-Reseat mechanism for the stem can be used in the instant invention for sealing the fluid flow passageway from the body cavity in the fluid flow closed as well as fluid flow open position of the valve.

In the valve of prior art, the gate reciprocates along the stem axis and requires plenty of space above the fluid flow path to accommodate the bonnet and the handwheel in a vertical installation which becomes a big problem in confined spaces for the installation of the valve. In the present invention, the gate does not reciprocate along the stem axis between the open and closed positions of the valve. However, in the Lift-and-Turn or the Lift-Turn-and-Reseat mechanisms to be used in the present invention, the axial motion of the stem and hence of the gate, is very limited, and limited only to the extent of loading the gate for sealing and unloading the gate of stem force for the purpose of facilitating movement of the flow control member between open and closed positions of the valve. The movement of the flow control member in a direction transverse to the stem axis selectively opens or closes the fluid flow passageway.

An object of the present invention is to provide a valve in which a tapered wedge gate reciprocates across the fluid flow path in a direction transverse to the stem axis.

A further object of the present invention is to provide a tapered wedge gate valve which can be used for fluids with particles in suspension.

Another object of the present invention is to provide a valve in which a tapered gate rotates about an offset axis parallel to stem axis.

Another object of the present invention is to provide a valve in which the dead cavity space is kept to the minimum.

Still another object of the present invention is to provide a reciprocating wedge gate valve that is actuated by a rotary stem.

Other objects and advantages of the present invention will become apparent as the following detailed description is read in conjunction with the accompanying drawings which illustrate certain preferred embodiments.

Brief Description of the Drawings

Fig.1 is a partially detailed cross sectional view of a reciprocating wedge gate valve of Prior Art.

Figs. 2, 3, 4 are partially detailed cross sectional views of different embodiments of a rotary wedge gate valve constructed in accordance with the present invention.

Fig. 2A is a cross sectional view taken along 2A-2A in Fig.2.

Fig. 3A is a cross sectional view taken along 3A-3A in Fig.3.

Fig. 4A is a cross sectional view taken along 4A-4A in Fig.4.

Fig. 5 is a partially detailed cross sectional view of a reciprocating wedge gate valve constructed in accordance with the present invention.

Fig. 5A is a cross sectional view taken along 5A-5A in Fig.5.

Detailed Description

Fig. 1 shows a prior art valve using a traditional wedge gate that reciprocates along the stem axis between open and closed positions of the valve.

The valve assembly 100 comprises a valve body 110 having a fluid flow passageway 112-114 defining a fluid flow path through the valve body and having a body cavity 118 in the fluid flow path. The body cavity 118 is in fluid communication with the fluid flow passageway 112-114 and opens upwardly to the interior of the bonnet 138. The valve body 110 has a pair of seating surfaces 140, 142 surrounding the fluid flow passageway and facing each other across the body cavity 118. In the body cavity 118 is placed a flow control member in the form of tapered solid wedge gate 124 which reciprocates along the axis of the stem 122 between open and closed positions of the valve. The gate 124 has tapered sealing surfaces 148, 150 which wedge against the body seating surfaces 140, 142 to sealingly close the fluid flow passageway 112-114.

More often than not, when the gate 124 is mechanically wedged against the body seating surfaces 140, 142, particles in suspension in the fluid get trapped between the sealing surfaces 148/140 and 150/142, thereby compromising sealing integrity. Therefore the valve of Fig. 1 is not very suitable for slurries. Moreover, a large body cavity space needs to be provided for in order to accommodate the reciprocating motion of the gate 124 along the stem axis. This is to the detriment of the use of valve in sanitary applications.

In Figs. 2,2A a rotary wedge gate valve is shown as constructed in accordance with the present invention and the valve is shown in the closed position.

The valve assembly 200 includes a valve body 210 having a fluid flow passageway defining a fluid flow path through the valve body and having a body cavity 218 in the fluid flow path. The body cavity 218 is in fluid communication with the fluid flow passageway and also opens upwardly to communicate with the interior of the bonnet 238. The valve body 210 comprises valve body seating surfaces 240, 242 facing each other across the body cavity 218 and surrounding the fluid flow passageway.

A flow control member 220 is disposed in the body cavity 218 and is actuated by the stem 222 to selectively open or close the fluid flow passageway 212-214. The flow control member 220 comprises a closure member 224 in the form of a wedge gate with an outer convex surface 250 on one side of the gate 224 and an inner concave surface 248 on the opposite side thereof facing the body seating surfaces 242, 240 respectively. The outer convex surface 250 is inclined to the fluid flow path 212-214 thereby making the gate 224 a part of the frustum of a hollow cone. The gate surfaces 248, 250 are concentric with each other and with the axis of the stem 222. The gate 224 is rotatable about the stem axis 222 and has a solid portion 225 to close the fluid flow passageway and a hollow conduit 244 alignable with the fluid flow passageway 212-214 to open the fluid flow. The valve body cavity 218 is shaped to closely surround the flow control member 220 and to permit the flow control member to rotate about the stem axis and to permit the flow control member move axially to wedge against the body seating surfaces 240, 242.

The stem 222 is integrally connected with the wedge gate 224 so that the stem 222 and the gate 224 move synchronously. The stem 222 is operatively connected with a valve operator (not shown) by means of a stem moving means which is in the form of a Lift-and-Turn mechanism that makes the stem move in a sequence of steps that provides only axial motion and then rotary motion in response to movement of the valve operator in one direction, and rotary motion and then only axial motion in response to movement of the valve operator in another direction. The axial motion of the stem causes the gate 224 to wedge against the body seating surfaces 240, 242 in order to sealingly close the fluid flow passageway 212-214. To open the fluid flow passageway, the gate 224 is lifted and then rotated. Lifting of the gate before rotation relieves the wedging load on the body seats 240, 242 thereby facilitating rotation of the gate 224. The stem moving means

is not shown in Figs. 2,2A for the sake of simplicity, but is denoted by the directional arrows on the stem 222.

There are different kinds of generic stem moving mechanisms that can be used with the instant invention. These mechanisms are in the form of a Lift-and-Turn mechanism or a Lift-Turn-and-Reseat mechanism. A Lift-and-Turn mechanism is explained in US Patent No. 5,342,028 by Nevrekar and US Patent No. 2,076,841 by Heggem. A Lift-Turn-and-Reseat mechanism is explained in US Patent No. 2,392,880 by Reed. The connecting means between the stem and the gate can be of two types. In one type, the stem 222 is rigidly connected to the gate as shown in Fig. 2. In another type, the stem 222 can move axially relative to the gate 224 by means of splines or a tongue and groove joint as in a ball valve, whereby the stem pushes down to load the gate with stem force for wedging. When the stem 222 moves away from the gate 224, the gate is relieved of the wedging force of the stem thereby facilitating rotation of the gate 224.

By using the stem moving means of a Lift-Turn-and-Reseat mechanism, the stem 222 is lifted, then rotated and then reseated whereby the stem 222 loads the gate 224 with the fluid flow conduit 244 aligned with the fluid flow passageway 212-214, thereby sealing the fluid flow passageway from the body cavity in the fluid flow open position of the valve 200.

As explained earlier, the traditional wedge gate valve of Fig.1 cannot be used for slurries, etc. In the instant invention of Figs. 2, 2A, the gate 224 reciprocates transverse to the stem axis and thus the gate surfaces 248, 250 slide over the seating surfaces 240, 242 in a wiping action, similar to in a ball valve. This wiping action of the sealing surfaces permits the valve of the instant invention to be used for fluids with suspended particles, e.g. slurries. Secondly, the dead cavity space in the valve body 210 of the instant invention is kept to the absolute minimum. This is a distinct advantage for sanitary applications of the valve of the instant invention.

In Figs. 3, 3A another embodiment of the rotary wedge gate valve is shown as constructed in accordance with the present invention.

The valve assembly 300 is nearly identical to the valve assembly 200 of Figs. 2,2A except that the valve assembly 300 comprises two identical gates 324 and 326 oppositely disposed along the fluid flow path 312-314. For the sake of brevity, only relevant details are explained below for Figs. 3,3A.

The flow control member 320 comprises two wedge gates 324 and 326 disposed diametrically opposite to each other. The flow control member 320 is actuated by the stem 322 which is operatively connected with the valve operator handle (not shown) by means of a stem moving means in the form of a Lift-and-Turn or a Lift-Turn-and-Reseat mechanism denoted by the directional arrows on the stem 322. The wedge gate 324 wedges against the valve body seating surfaces 340, 342 and the wedge gate 326 wedges against the valve body seating surfaces 350, 352. The gates 324 and 326 are integrally connected to each other thereby making the flow control member a frustum of a hollow cone rotating over a trunnion 360 on the valve body. The trunnion 360 comprises a fluid flow conduit 346 therethrough which remains fixed, that is, non-rotating with the gate, as compared to a rotating conduit in a traditional solid plug valve. The gates 324 and 326 comprise a fluid flow opening in each and is alignable with the fluid flow conduit 346 in the trunnion 360 and also alignable with the fluid flow passageway 312-314 in the fluid flow open position of the valve assembly 300. Thus the closure member 320 basically comprises two gates which rotate synchronously in opposite directions across the fluid flow path 312-314. Because of the fully circular nature of the flow control member 320, machining of the valve body cavity 318 and of tne gates 324, 326 becomes less expensive than machining of the same in Figs. 2,2A. In Figs. 3,3A sealing takes place at four places along the fluid flow path compared to at 2 places in Figs 2,2A.

In Figs. 4,4A another embodiment of the rotary wedge gate valve is shown as constructed in accordance with the present invention. For the sake of brevity only relevant details are explained below for Figs. 4,4A.

The valve assembly 400 comprises a flow control member 420 which comprises a wedge gate 424 with a solid portion 425 to close the fluid flow passageway 412-414. The gate 424 comprises a convex outer sealing surface 450 facing the body seating surface 442 and an inner concave sealing surface 448 facing the body seating surface 440. The sealing surface 450 is inclined to the fluid flow path 412-414 and the gate 424 wedges into the valve body seating surfaces 440, 442 to sealingly close the fluid flow passageway 412-414 from the valve body cavity 418.

The gate 424 is actuated by the stem 422 the lower end of which is connected to a toothed pinion 432 which engages an arcuate toothed rack 430 on the inside upper rim of the rotary gate 424. The stem 422 is operatively connected with the valve operator handle (not shown) by means of a Lift-and-Turn or a Lift-Turn-and-Reseat mechanism for the stem moving means denoted by the directional arrows on the stem 422. The stem moving means selectively moves the stem which pushes the pinion 432 onto the gate detent 426 thereby wedging the gate 424 into the valve body seating surfaces 440, 442. The stem moving means causes the stem 422 to move in a sequence of steps that provides only axial motion and then rotary motion in response to movement of the valve operator in one direction, and rotary motion and then only axial motion in response to movement of the valve operator in another direction. Lifting of the stem 422 before rotation relieves the gate 424 of the stem force thereby facilitating rotation of the gate 424. The rotary motion of the stem 422 causes the gate 424 to rotate by virtue of the toothed engagement between the pinion 432 and the gate rack 430. The operating radius of the rack 430 is greater than the operating radius of the pinion 432 so that the gate 424 rotates about an axis parallel to and offset from the stem axis 422. The rotary motion of the gate 424 transverse to the stem axis selectively opens or closes the fluid flow passageway 412-414. The connecting means between the stem 422 and the gate 424 in Fig.4 is shown as a rack and pinion arrangement. However, any other suitably appropriate connection can be used, e.g. Scotch Yoke and Pin connection.

In Figs. 5,5A another embodiment of the wedge gate valve is shown as constructed in accordance with the present invention.

Most of the elements in Figs. 5,5A are similar to those in Figs. 4,4A and for the sake of brevity, only relevant details are explained below. The rack 530 on the gate 524 in Fig. 5 is a linearly straight rack which is engaged by the pinion 532. Therefore, the gate 524 reciprocates in a straight line direction transverse to the fluid flow path 512-514 and also transverse to the axis of the stem 522. The pinion 532 pushes onto the lower detent 526 to wedge the gate 524 into the valve body seating surfaces 540, 542. An upper detent 527 is provided overhanging onto the top of the pinion 532 in order to pull the gate 524 up by the stem 522 which is operatively connected with the valve operator handle (not shown) by means of a stem moving means. For the stem moving means a Lift-and-Turn or a Lift-Turn-and-Reseat mechanism is used and is denoted by the directional arrows on the stem 522. The stem moving means causes the stem 522 to move in a sequence of steps that provides only axial motion and then rotary motion in response to movement of the valve operator in one direction, and rotary motion and then only axial motion in response to movement of the valve operator in another direction. The axial motion of the stem causes wedging and unwedging of the gate 524 and the rotary motion of the stem 522 causes the gate 524 to reciprocate in a straight line direction transverse to the stem axis. The gate 524 has a fluid flow conduit 544 (Fig. 5A) alignable with the fluid flow passageway 512-514. A Lift-Turn-and-Reseat mechanism is used for sealing the fluid flow passageway 512-514 from the valve body cavity 518 in the fluid flow closed position as well as in the fluid flow open position of the valve 500 when the fluid flow conduit 544 is aligned with the fluid flow passageway 512-514. Since the gate 524 reciprocates in a straight line transverse to the stem axis, the sealing surfaces 548, 550 of the gate 524 are planar surfaces, whereas the sealing surfaces 448, 450 in Fig.4 are curved surfaces because of the rotary type gate 424.

It would be interesting to know that as the radius of the gate rack 430 in Figs. 4,4A is made larger and larger to infinity, the rotary gate 424 culminates into a gate 524 that reciprocates in a straight line transverse to the stem axis as shown in Figs. 5,5A. Thus, the rotary gate valve of Figs. 4,4A is transformed into the reciprocating gate valve of Figs. 5,5A by making the gate rack straight from a curved one.

The present invention is well adapted to carry out the objects and to attain the ends and advantages mentioned as well as those inherent therein. While presently preferred embodiments of the invention have been described for purposes of this disclosure, it will be recognized that numerous

changes can be made which readily suggest themselves to those skilled in the art and which are encompassed within the spirit of the invention disclosed as defined in the appended claims.

What is claimed:

1. A valve comprising:

a valve body having a fluid flow passageway defining a fluid flow path through the valve body and having a body cavity in the fluid flow path, the valve body having a pair of seating surfaces surrounding the fluid flow passageway and facing each other across the body cavity;

a flow control means disposed in the body cavity for selectively closing or opening the fluid flow passageway, the flow control means comprising:

a gate having a convex surface facing one seating surface and a concave surface facing the second seating surface, the surfaces being disposed concentric with each other and at least one of the surfaces disposed inclined to the fluid flow path, the valve body cavity correspondingly shaped to closely surround the flow control means and to permit the flow control means to rotate about and to move axially along an axis transverse to the fluid flow path; and

a valve operator means connected to the flow control means for selectively moving the flow control means, the valve operator means comprising:

a valve operator;

a stem having a stem axis and a stem diameter, the stem connected to the flow control means by a connecting means that permits substantially no rotary movement between the stem and the flow control means; and

a stem moving means operatively connected with the valve operator and the stem for selectively moving the stem, said stem moving means causing a rotary movement of the flow control means for selectively closing or opening the fluid flow passageway and further causing the stem to move axially to force the flow control means to wedge against the seating surface facing the inclined surface of the gate for sealing about the fluid flow passageway.

2. The valve of Claim 1 wherein the connecting means between the flow control means and the stem comprises a rack and pinion arrangement between the flow control means and the stem.

3. The valve of Claim 1 wherein the stem moving means causes the stem to move in a sequence of steps that provides only axial motion and then rotary motion in response to movement of the valve operator in one direction, and rotary motion and then only axial motion in response to movement of the valve operator in another direction.

4. The valve of Claim 1 wherein the flow control means comprises a fluid flow conduit therethrough alignable with the fluid flow passageway.

5. The valve of Claim 1 wherein the inclined surface of the gate is formed from the frustum of a cone.

6. The valve of Claim 1 wherein the connecting means between the stem and the flow control means comprises means for causing the flow control means to rotate about an offset axis parallel to the stem axis.

7. The valve of Claim 1 wherein the connecting means between the stem and the flow control means comprises means for causing the flow control means to rotate about an offset axis parallel to the stem axis and offset from the stem axis by a distance that is at least ten thousand times the stem diameter.

8. A valve comprising:

a valve body having a fluid flow passageway defining a fluid flow path through the valve body and having a body cavity in the fluid flow path, the valve body having a pair of seating surfaces surrounding the fluid flow passageway and facing each other across the body cavity;

a flow control means disposed in the body cavity for selectively closing or opening the fluid flow passageway, the flow control means comprising:

a gate having a first planar face on one side of the gate facing one seating surface and a second planar face on an opposite side thereof facing the second seating surface and at least one of the faces of the gate disposed inclined to the fluid flow path, the valve body cavity correspondingly shaped to closely surround the flow control means and to permit the flow control means to move axially along an axis transverse to the fluid flow path and to further permit the flow control means to reciprocate in a straight line direction transverse to said axis; and

a valve operator means connected to the flow control means for selectively moving the flow control means, the valve operator means comprising:

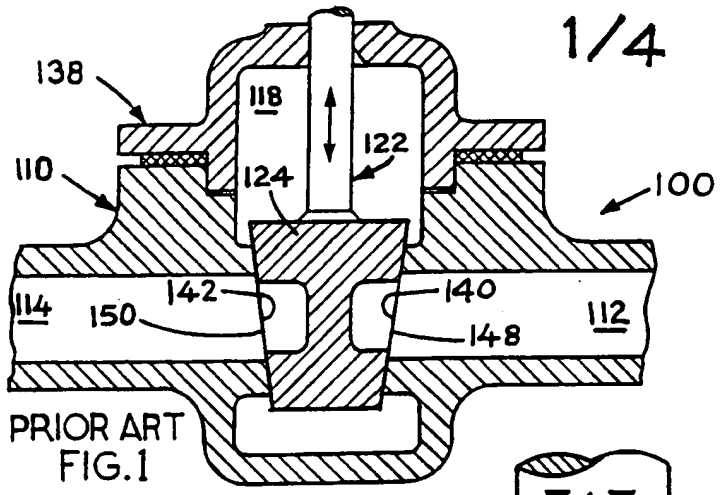
a valve operator;

a stem having a stem axis, the stem connected to the flow control means by a connecting means that permits substantially no rotary movement of the stem when the flow control means is held stationary; and

a stem moving means operatively connected with the valve operator and the stem for selectively moving the stem, said stem moving means causing the flow control means to reciprocate in a linearly straight direction transverse to the stem axis for selectively closing or opening the fluid flow passageway and further causing the stem to move axially to force the flow control means to wedge against the seating surface facing the inclined face of the gate for sealing about the fluid flow passageway.

9. The valve of Claim 8 wherein the connecting means between the flow control means and the stem comprises a rack and pinion arrangement between the flow control means and the stem.

10. The valve of Claim 8 wherein the stem moving means causes the stem to move in a sequence of steps that provides only axial motion and then rotary motion in response to movement of the valve operator in one direction, and rotary motion and then only axial motion in response to movement of the valve operator in another direction.



PRIOR ART
FIG. 1

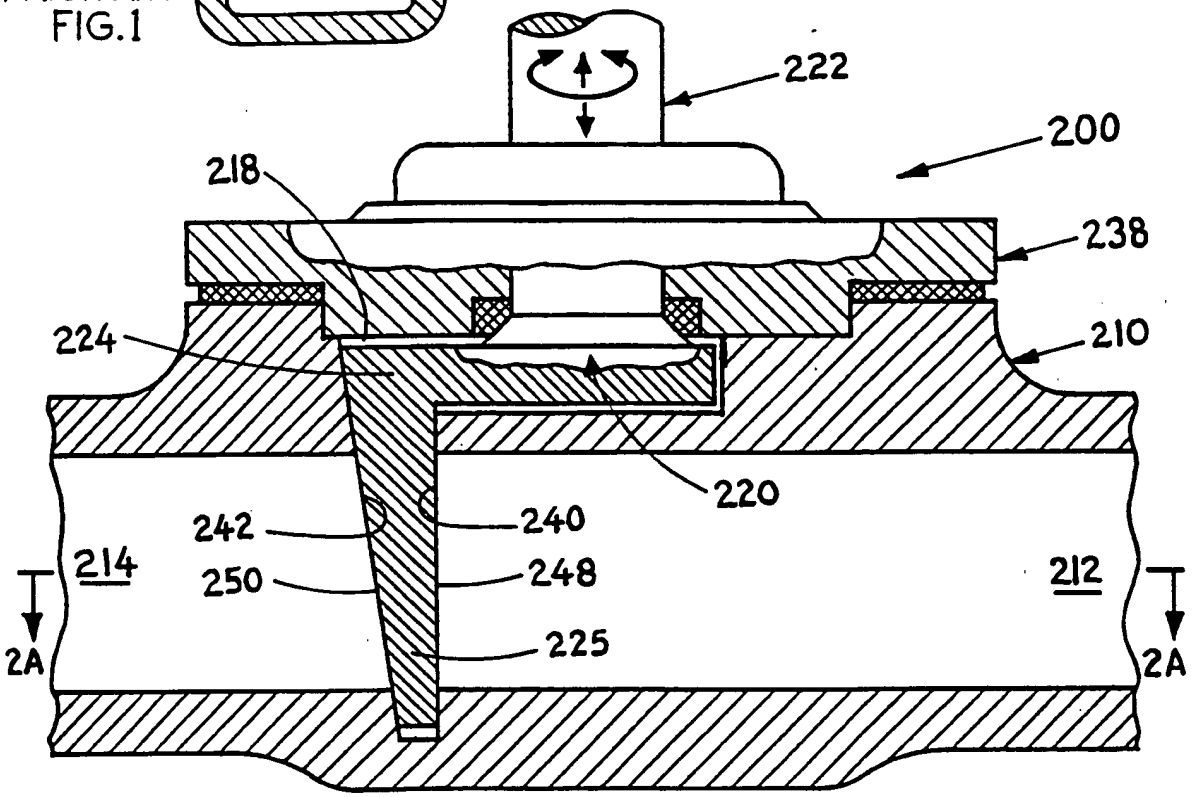


FIG. 2

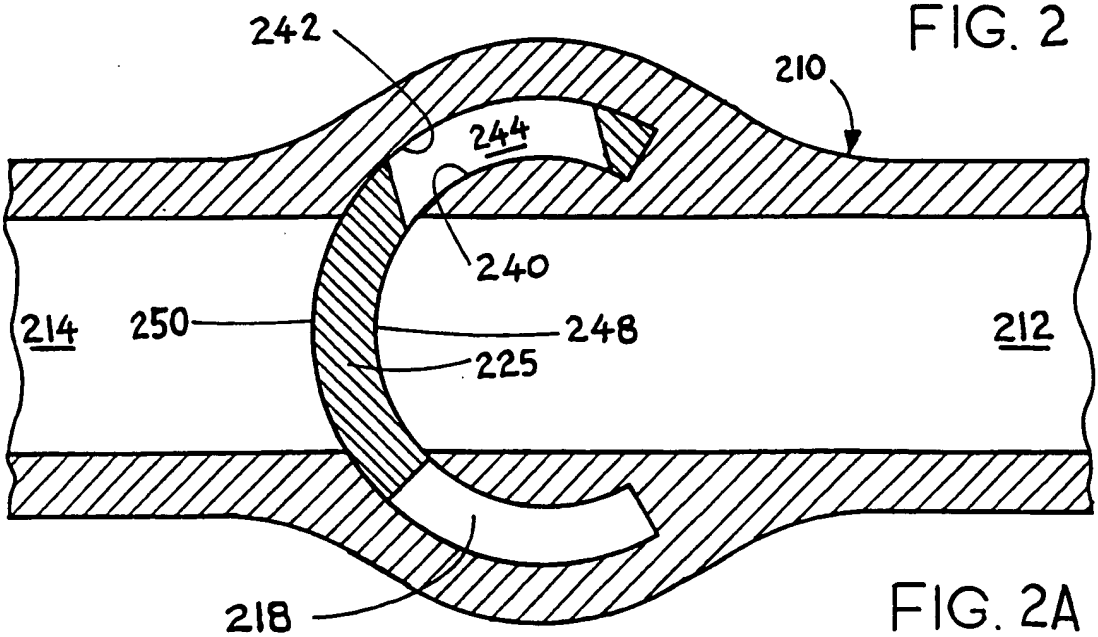
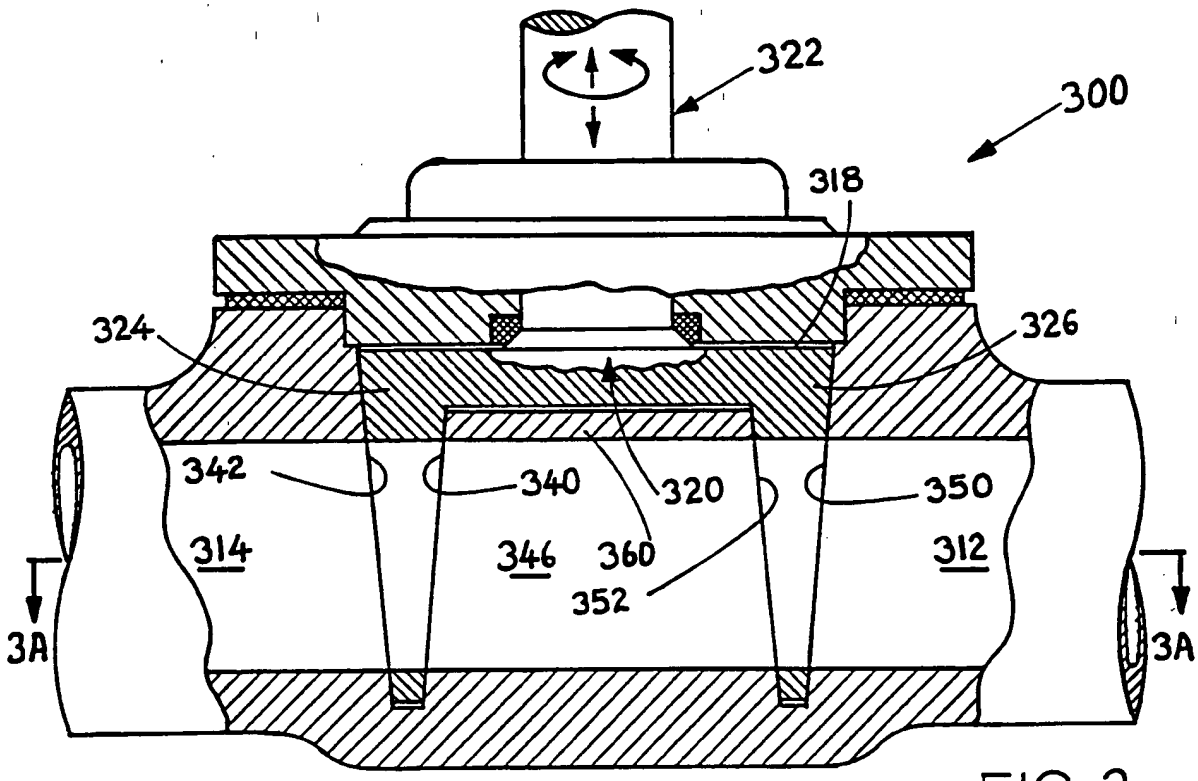


FIG. 2A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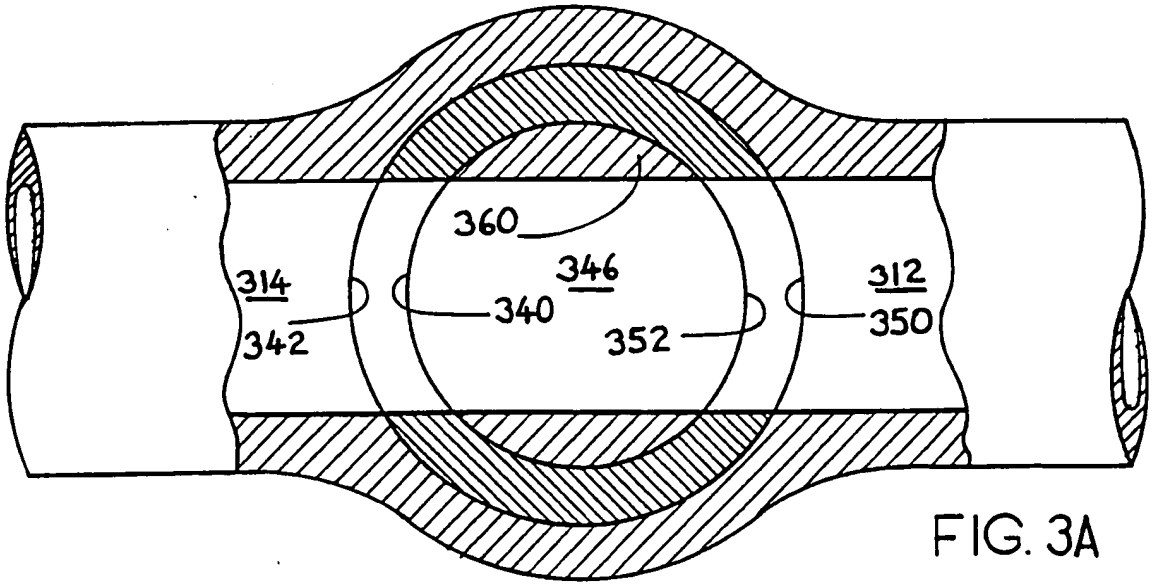
360
312
352
3A
3A

FIG. 3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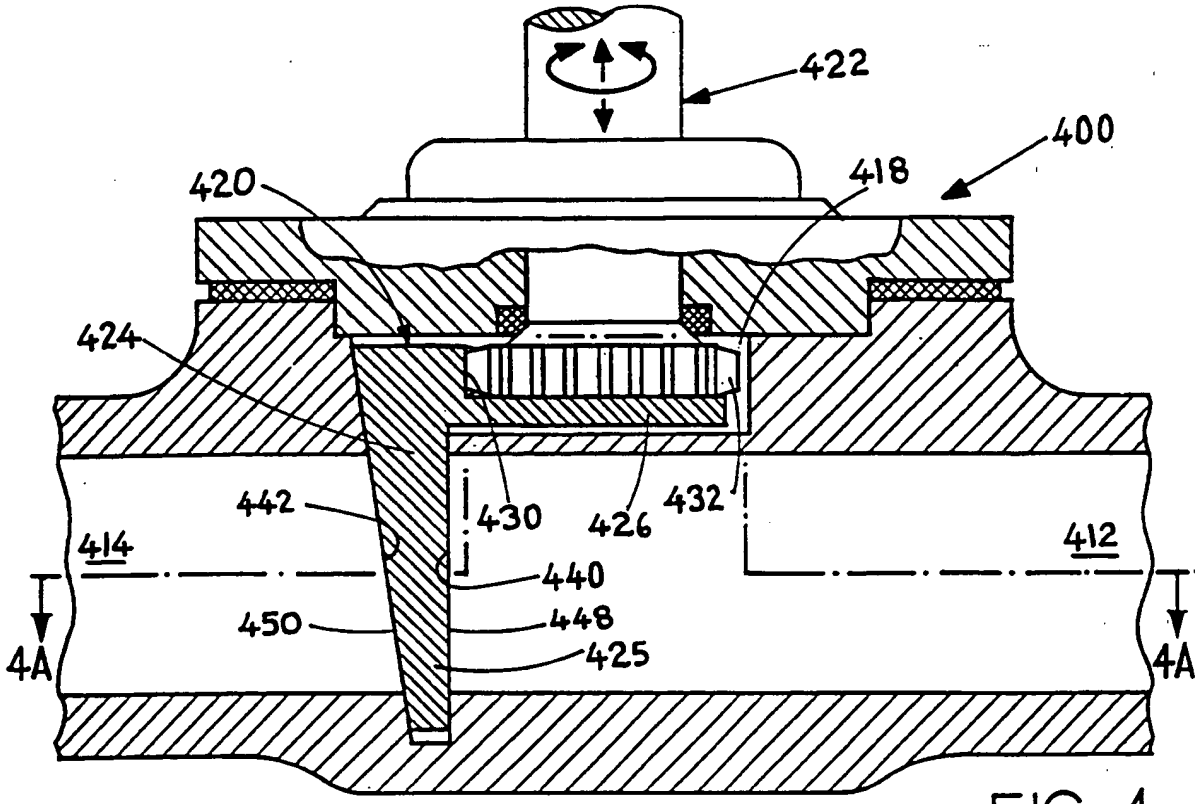
346
314
340
312
342
352
350

FIG. 3A


422
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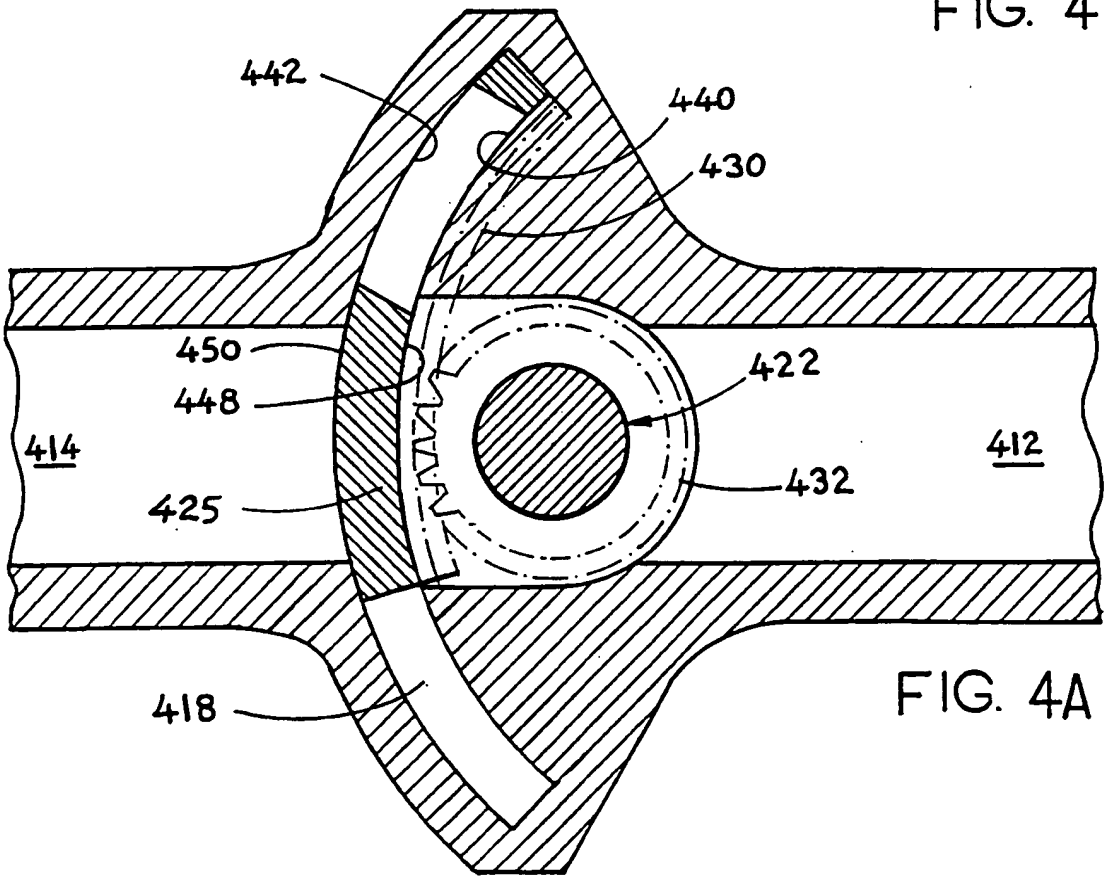
418
424
442
430
426
432
414
412
440
450
448
425
4A
4A

FIG. 4


442
440
430
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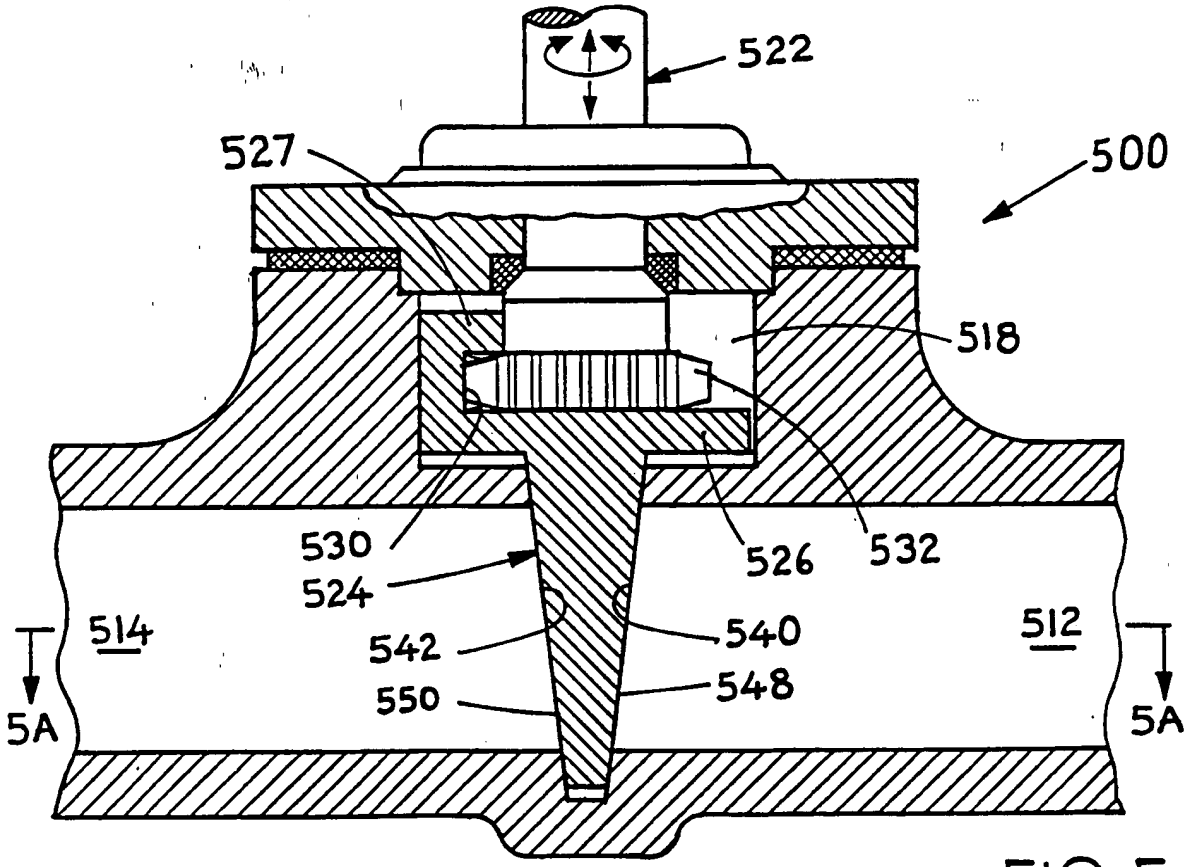
448
422
414
412
425
432
418

FIG. 4A


522
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524
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512
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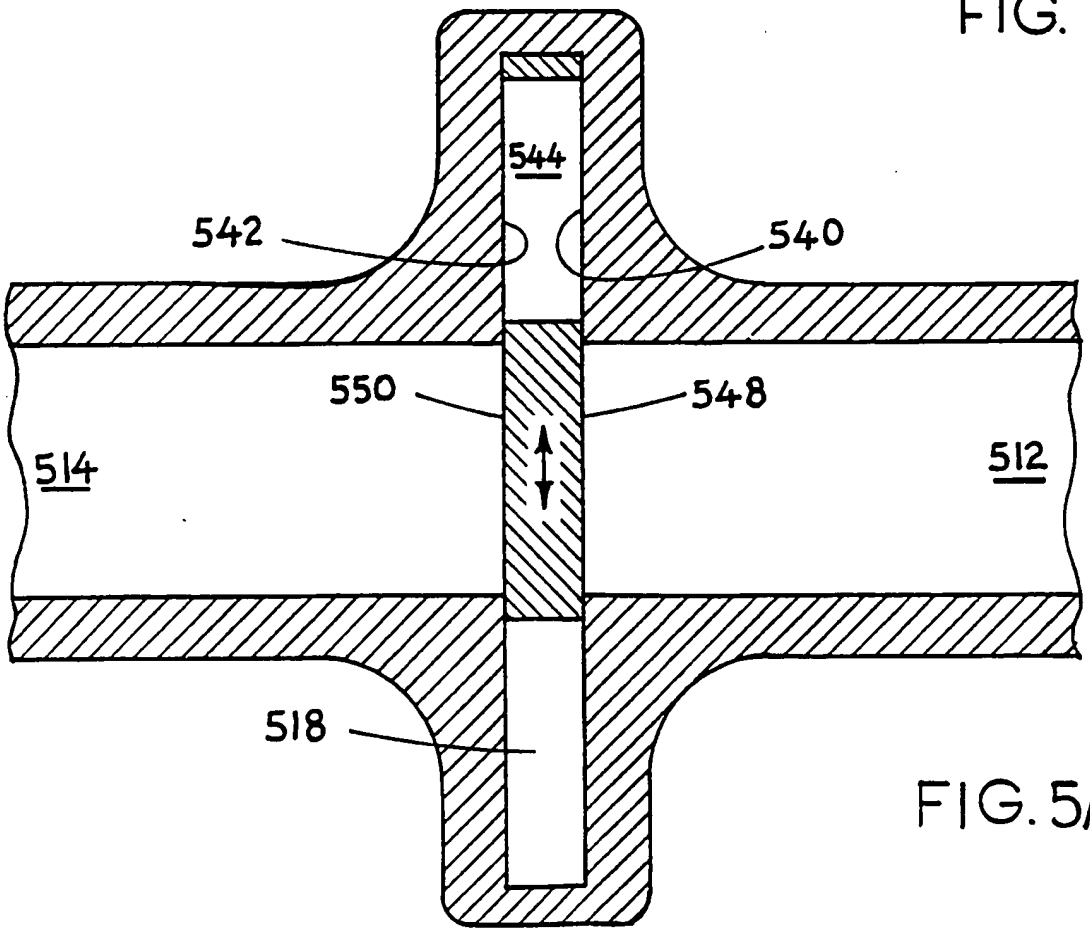
548
5A
5A

FIG. 5


544
542
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514
512
518

FIG. 5A

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/06097

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) :F16K 3/02, 3/22
US CL : 251/203, 250.5, 302, 327
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 251/162, 163, 164, 187, 192, 193, 195, 203, 250.5, 302, 327

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 1,185,789 A (GARBE) 06 June 1916.	1-10
A	US 1,695,014 A (HEGGEM) 11 December 1928.	1-10
A	US 1,933,182 A (PAGON et al) 31 October 1933.	1-10
A	US 1,951,878 A (LUNDGREN) 20 March 1934.	1-10
A	US 2,263,617 A (DANIEL) 25 November 1941.	1-10
A	US 2,850,260 A (PERAZONE et al) 02 September 1958.	1-10
A	US 3,318,568 A (BLOMSTRAN) 09 May 1967.	1-10
X,E	US 5,618,027 A (NEVREKAR) 08 April 1997.	1-10

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 20 MAY 1997	Date of mailing of the international search report 11 JUL 1997
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer /s/ Hurley for JOHN RIVELL Telephone No. (703) 308-2599

Form PCT/ISA/210 (second sheet)(July 1992)★